INVESTIGATION OF RESPIRATORY PROBLEMS AT ALCOM LTD, PORT COLBORNE, ONTARIO

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SUMMARY

The Ministry of Labour (MOL) received a request from management for assistance in determining the prevalence and etiology of respiratory problems at Alcom Ltd, Port Colborne, Ontario. Because the recognition of the symptoms dated from late 1988 which coincided with the introduction and increased use earlier that year of two new epoxy resin hardeners containing tetrachlorophthalic anhydride (TCPA) (one of a class of chemicals known to be respiratory sensitizers), attention focussed on this substance. In response to the request, the MOL conducted a two-phase cross-sectional investigation, consisting of air sampling, questionnaire and pulmonary function (breathing tests) involving 52 current workers in July 1990, and determinations of specific antibody against TCPA in serum samples obtained in October 1990, performed by the University of Cincinnati Medical Center. The four exposure or job areas were considered to be (in order of decreasing exposure to TCPA) moulders, those intermittently in the plant (maintenance, supervisors, etc), coil assembly and office/ engineers.

Air sampling for TCPA revealed exposure in all production areas of the plant, with mean concentrations ranging from 0.20 - 0.40 mg/m^3 in sampling in October 1989 and May 1990, but was much lower, ranging from 0.009 to 0.13 mg/m^3 at the time of the survey in July, at which time it was greatest in premoulding.

Respiratory symptoms (wheeze, shortness of breath, chest tightness) that were considered to be work-related were reported by 27 to 35% of participants, and were most frequent in the mould group, followed by coil assembly. There were only 2 (3.9%) of 52 participants with abnormal (obstructive) patterns on baseline spirometry, both smokers. Moreover, baseline spirometry did not differ between exposure groups. Six (11.5%) of the subjects demonstrated a "significant" (greater than 10%) decline in forced expiratory volume in 1 second (FEV_1) over the shift; all were in coil assembly and none were in the mould or intermittent groups (where there was greatest potential for exposure to TCPA). However, as noted, exposures on the day of the survey were documented to be lower than previously.

The meaning of a positive antibody test is explained in the text. Positive IgE antibody was found in 15 (30%) and IgG in 19 (38%) of 50 subjects in whom blood was drawn. There was no relation between positive antibody and reported work-related symptoms, baseline breathing tests, or decline in FEV_1 over the shift. However, there was an association with exposure group and antibody positivity, being found among 3 (43%) of the mould, 4 (67%) of the intermittent, 8 (24%) of the coil assembly, and 0 of the 4 office workers. Moreover, none of

those hired within 4 months of the October blood sampling phase tested positive. Among the 40 subjects who had been hired since 1988 when use of TCPA increased and had serum drawn, there was a significant trend to an increasing proportion having positive IgE antibody with increasing duration of employment. In addition, among this group, those with positive IgE had been employed, on average, significantly longer (1.6 years) than those without such antibody (1.0 years).

In summary, respiratory symptoms were frequent and most appeared to be "work-related". That TCPA played a role in the respiratory problems was suggested by a number of factors including (i) the temporal onset with increased use TCPA use and introduction of new epoxy hardeners, (ii) absence of positive antibody results among the least exposed office workers, (iii) the trend of positive antibody results with duration of employment since increased TCPA use, (iv) the highest prevalence of antibody in the mould and intermittently exposed groups, and (v) anecdotal reports of fewer symptoms during the most recent winter since TCPA exposures have been lower. The fact that new hires have not been sensitized may imply that more recent lower exposures (and recently taken measures such as ventilation) will prevent sensitization but may also be consistent with insufficient time to become sensitized.

Current exposures following installation of local ventilation are now below the MOL Working Exposure Guideline of 0.1 mg/m^3 which is also the level below which no "true" cases of TCPA-induced occupational asthma were found to react on direct challenge with TCPA in inhalation testing in a recent British study. To ensure that control measures are adequate and to assess whether symptoms, sensitization or adverse respiratory conditions have developed, it is reasonable to follow-up with respiratory questionnaires, breathing tests, and antibody determinations within a year among new hires, and among those with positive antibody determinations.

ABBREVIATIONS

MOL	Ministry of Labour
OA	occupational asthma
TCPA	tetrachlorophthalic anhydride
WCB	Workers' Compensation Board
FEV_1	forced expiratory volume in 1 second
FVC	forced vital capacity
JHSC	Joint Health and Safety Committee
NIOSH	National Institute for Occupational Safety and Health
WEG	Working Exposure Guideline
p value	This represents the probability that the data observed could have occurred by chance if the null hypothesis (i.e. no difference between or no effect of exposure groups) is true. A p value of less than 0.05, if the null hypothesis is true, means the probability that the data would show up as they did is less than 1 in 20 (the conventional level of "statistical significance"). P values greater than 0.05 mean the probability of the data showing up as they did is greater than 1 in 20 (or compatible with chance).
Percent of predicted	The performance on a breathing test as a percentage of normal for sex, age and height. For FEV_1, "normal" is usually defined as greater than 80% of predicted.

INTRODUCTION

In April 1990, the Health and Safety Studies Unit (HSSU) of the Ministry of Labour (MOL) was contacted by the Manager, Human Resources, Ascolectric Limited regarding breathing problems at Alcom Limited, Port Colborne, Ontario. A two phase cross-sectional survey was conducted, consisting of a questionnaire and lung function tests in July, and testing for antibody against tetrachlorophthalic anhydride (TCPA) in serum in October 1990. The purpose of this report is to summarize the findings of the survey for the Joint Health and Safety Committee (JHSC) and the entire workforce.

BACKGROUND

In response to the request for assistance, a meeting was held between MOL investigators and the Joint Health and Safety Committee (JHSC) in June 1990. It was learned that the symptoms had been recognized about October 1988. Earlier in 1988, the company had introduced two new epoxy resin hardeners containing TCPA, although TCPA had been used in other hardeners since the plant opened. In addition, production volume had approximately doubled since 1988. TCPA is one of a class of compounds known to be respiratory sensitizers and to be a cause of occupational asthma (OA). For these reasons, it had been suggested that the symptoms may have been due to OA caused by TCPA or some other substance in the work environment.

The situation was complicated by 1) rotation of workers between jobs; and 2) the presence of other sensitizers: small quantities of isocyanates are used in a print ink and rosin flux is used in a soldering operation. By mid-summer 1990, at least four WCB claims had been accepted, and there was considerable concern at the plant. In response to the request from management, and after consulting with the JHSC, the MOL initiated an investigation with an initial phase that involved a questionnaire, lung function testing and air sampling. A protocol was developed, reviewed by the JHSC, and discussed at a meeting with employees in the week prior to the survey, which was undertaken in July 1990.

Process

Alcom, a division of Ascolectric, has manufactured solenoid coils at its present site since 1984. Solenoid coils are manufactured by winding copper wire on bobbins, soldering the copper wires to terminals, mechanically crimping lead wires, placing coils into metal fixtures to form the

solenoid, and then embedding the metal fixture into an epoxy resin casing. The copper wires are soldered by dipping into unheated rosin flux (49% isopropyl alcohol, 50% colophony) and then into a small lead solder pot (60% tin, 40% lead), heated to 950°F (510°C).

The epoxy resin utilized is a mixture of TCPA and silica. The resin is received in bags of granules which are compressed into pills by a preformer machine. The pills are then preheated and placed inside a moulding machine, together with the solenoid assembly. Moulding then takes place for 3.5 minutes at 330 to 350°F (166-177°C). After moulding the parts are deflashed, inspected and marked. Marking is done either by hot stamping the epoxy casing or by printing with a two-component ink containing 0.7% toluene diisocyanate (TDI).

Local mechanical exhaust ventilation is provided for the soldering pots, hot stamping and printing work stations. Installation of ventilation for moulding presses commenced in July 1990 and was completed by October 1990.

OBJECTIVES:

The objectives of the investigation were to determine 1) how many current employees reported breathing problems; 2) whether the breathing problems could be related to work; and 3) whether these problems could be associated with a specific job or substance, and in particular whether sensitization with TCPA was responsible.

METHODS

Environmental measurements

Air sampling and analysis on the day of the July survey for TCPA was performed according to standard NIOSH techniques by measuring both personal and area exposures in the preforming, moulding, winding, soldering and finishing areas.

Medical assessments

Phase 1: July survey: A cross-sectional evaluation was offered to all current employees; available information was also collected regarding the past respiratory WCB claims. The

evaluation consisted of a work exposure and medical questionnaire; and pulmonary function testing performed before, 1 hour into, and after the shift. The questionnaire was adapted from one used in NIOSH evaluations (Smith et al, 1987). A chest symptom (i.e. wheeze, shortness of breath, or chest tightness) was considered work-related if (i) the onset was after starting at Alcom; (ii) the subject reported temporal change with weekends and vacations; and (iii) it followed certain activities or exposures at work. Occupational asthma (OA) was considered to be present by questionnaire if two or more work-related symptoms were reported.

Spirometry was measured using a Vitalograph spirometer; forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1) and FEV_1/FVC ratio were determined. We considered a 10% or greater decrease in FEV_1 across the work shift to be a positive response.

Phase 2: October survey for serology: Despite the high symptom prevalence in the survey, one could not be certain that TCPA was responsible or had induced sensitization. Consequently, blood specimens were collected in October 1990 for determinations of specific IgE and IgG antibodies to TCPA performed at the University of Cincinnati Medical Center. Due to turnover in personnel and absence during the July survey, not all employees participated in both phases of the survey.

Notification: A summary of the July survey findings was presented to the JHSC and to all workers in September 1990. Letters containing individual pulmonary function results were distributed in October 1990, and notification of individual serology results are being distributed with this report.

Statistical analyses: The Statistical Analysis System (SAS) was used for all analyses except for linear trend in proportions where True Epistat was used. For categorical data, chi-square and logistic regression, and for continuous data, linear regression were used.

RESULTS

Review of WCB claims: All four claims were accepted by the WCB. It was known that one claimant had had a positive challenge to colophony; the etiologic agents for OA for the other three are not known but for one, TCPA was definitely suspected by the respiratory specialist

to be the cause. None were still employed at the company.

Phase 1: July survey

Environmental

On air sampling, isocyanates in the printing ink, and formaldehyde (a marker for breakdown products of colophony) were undetectable. Results of TCPA exposure data are listed in Table 1. TCPA was detectable throughout the plant.

Exposure Classification

With respect to current exposure to TCPA, discussion with Alcom staff revealed that there were four "JOBCODEs or groups", presented here in what is considered to be decreasing likelihood of frequency and degree of TCPA exposure:

> 1) Moulders; 2) those intermittently in all areas of the plant who may have activities at or near the TCPA area (e.g. electrician, utility, maintenance, some technicians and inspectors, supervisors); 3) Coil Assembly; and 4) those in the office and engineering, who spent little or no time in TCPA areas.

The numbers in each group participating in the July survey were 7, 6, 33, and 6, respectively. If considered on the basis of currently or previously in moulding in the year prior to the survey, one subject from group 3 would be in group 1. The current exposure classification is used for reporting of symptoms and breathing tests; the previous/ current classification is used for TCPA antibody.

Participants

A total of 52 current employees participated in the survey, representing 79% of the 66 eligible. Reasons for not participating included refusal (3 employees), absent or on holiday (3), on compensation or injury (7), and on maternity leave (1). The ages of the examined employees ranged from 16 to 67 years (mean 35.2); 83% were female. They had worked an average 2.5 years at the plant (range 0.1 to 8.1).

Symptoms reported

There was a high prevalence of reported respiratory symptoms on the questionnaire (Table 2). Wheeze was reported by 29 (56%), shortness of breath by 25 (48%), and chest tightness by 29 (56%). These symptoms were reported to be work-related (as defined above) by 14, 15, and

20 subjects, respectively, and OA was reported by 18 (35%). In general, wheeze, chest tightness, and OA were reported most frequently by the Mould workers, but there were few subjects in all groups except Coil Assembly.

Smoking and symptoms: Current smoking was reported by 27 (52%) of participants, while 18 (35%) reported to be never-smokers, and 7 (14%) were ex-smokers (Tables 2 and 3); the proportion of current smokers was highest in the mould group (Table 2) and thus represents a confounding factor. There was no difference in the prevalence of reported work-related shortness of breath and chest tightness among the smoking groups but wheeze and OA were reported approximately twice as frequently in smokers and ex-smokers (Table 3).

Symptoms after controlling for smoking: As shown in Table 2, after adjusting for smoking status, the differences between groups in reported work-related symptomse were not statistically significant.

Spirometry (breathing tests)

Baseline (i.e. pre-shift):

(a) Obstruction: Only 2 (3.9%) of 52 participants had an abnormal (obstructive) pattern on spirometry (defined as FEV_1/FVC ratio < 70%), one in each of the mould and intermittently exposed groups. One of these was a current smoker, the other an ex-smoker, with 28 and 37 pack-years of smoking, respectively.

(b) Baseline breathing capacity was lower in the ex-smokers and current smokers as expected. Mean FEV_1 percent of predicted was lowest in Group 2 (intermittent exposure) and highest in the office group; however, after adjusting statistically for pack years of smoking, there was no significant difference among exposure groups (Table 4).

Change in lung function over the shift: Although the average decline in FEV_1 was greatest in the Mould group, the difference between groups was not significant (Table 4). Only 6 (11.5%) of the 52 subjects demonstrated a "significant" decline in FEV_1 (defined as greater than 10% over the shift); all 6 worked in coil assembly. Thus, none of those in Groups 1 and 2, with the greatest potential TCPA exposure had such a decline but as noted in Table 1, TCPA exposure was low on the day of the survey. The prevalence of 10% decline was similar across smoking groups (Table 3).

Phase 2: October survey

Participants

Blood specimens were collected from 52 persons; of these one was labelled as "not available" for analysis by the University of Cincinnati, and one was a child of an employee (these are not further addressed). One other subject was a former employee (a WCB OA claimant) who is included in the analyses by department. Of the remaining 49 providing specimens, 40 had participated in the July survey, 4 had been hired since the survey, and 5 were absent or non-participants in the survey. Frozen serum samples, previously obtained at McMaster University from two former employees (WCB OA claimants) were later forwarded to Cincinnati but were not analyzed with these samples.

Meaning of "positive result": Antibodies are proteins (immunoglobulins) synthesized by the body in response to foreign material (Figure). For example, after having measles, one develops specific antibodies directed against the measles virus, and individuals with hay fever allergies have specific antibodies against ragweed. In the present situation, the presence of specific IgG antibody against TCPA simply indicates that the individual has been "exposed" to the material (i.e. a marker of exposure) but does not imply the presence of disease. The presence of IgE antibodies usually signifies sensitization (allergy) to TCPA; they may be associated with, but do not necessarily mean, that the person has symptoms or disease.

Numbers positive for antibody: Of the 50 subjects on whom serum was drawn, 15 (30%) were positive for specific TCPA IgE antibody, and 19 (38%) had IgG antibody. Among the 40 subjects having serum drawn who participated in the July survey, the corresponding numbers with antibody were 14 (35%) and 17 (43%), respectively.

The relation between presence of antibodies and reported symptoms and change in FEV1 over the shift: As seen in Table 5, there was no relationship between reported work-related symptoms, baseline spirometry, or decline of FEV, > 10%, and positive antibody status.

Smoking and antibody status: Antibody status according to smoking habit among the 40 serum participants is shown in Table 5. Among those with IgE antibody, there were higher proportions of never and ex-smokers than among those without antibody; a similar pattern was seen for IgG. The corollary was that among never and ex-smokers there were significantly

higher proportions positive for IgE antibody (50% and 57%) respectively, than among current smokers (16%).

The relation between specific antibodies and exposure group: Of the 50 samples available, the proportion with positive IgE (and IgG) antibody was highest in the groups with most direct exposure, moulders and those who moved all over the plant (Groups 1 and 2), intermediate in coil assembly, and negative in the small office group (Table 6A). The difference among groups was of borderline statistical significance ($p=0.085$ for IgE). There was a trend to increasing proportion with positive antibody status with "greater potential" for TCPA exposure. However, there was no difference in average duration among those positive and negative for IgE antibody (Table 5). Those hired within 4 months of blood sampling were negative. When antibody positivity was examined among the 40 July participants with smoking habit known, exposure group was not significantly associated with being antibody positive after controlling for smoking status.

A separate analysis was performed among the 36 subjects hired since 1988, coinciding with the introduction of new hardeners and the increase in volume of TCPA used. Duration of employment was categorized as follows:

1. less than 0.33 years (those hired since July 1990 when air sampling first demonstrated that exposure was low);
2. 0.33-1.33 years (employed for up to 1 year prior to lower exposures being demonstrated);
3. greater than 1.33 years (employed for greater than 1 year prior to lower exposures being demonstrated).

As shown in Table 6B, there was an increasing trend in the proportion of those with positive IgE (and IgG) antibody, with increasing duration of employment group, increasing from 0 (of 5 positive for IgE among those employed less than 0.33 years), to 4 (25%) of 16 employed 0.33 to 1.33 years, and 8 (53%) of 15 for those employed greater than 1.33 years (p for trend = 0.019). Moreover, mean duration of employment among those hired since 1988 was significantly greater among those IgE positive (Table 5). Among the smaller group of July participants with smoking habit known (29 subjects), none were employed less than 0.33 years. However, compared to those employed less than 1.33 years, the prevalence of IgE positivity was almost twice as great among those employed at least 1.33 years in both current and non-current smokers, but the association was not "statistically significant".

DISCUSSION

The findings can be summarized according to the objectives above: 1) how many employees reported breathing problems; 2) whether these problems were related to work; and 3) whether these problems were associated with a specific job or substance.

1. **Reporting of chest symptoms:** Asthma can be defined as reversible airways obstruction. The survey found a high prevalence of reported chest symptoms of wheeze, shortness of breath and chest tightness, that may be, but are not always indicative of asthma. As a result of the decision to proceed with the survey prior to the July shut down because of the real concerns among the workforce about the symptoms, and the impending introduction of ventilation, it was not possible to incorporate into the protocol a test of airways reactivity such as peak flow studies. Thus, it must be borne in mind that these reported symptoms cannot be objectively confirmed.

2. **Work-relatedness of symptoms:** An important proportion of the symptoms appeared to be work-related according to the definition in the Methods section. However, this does not indicate what specific process or exposure may be responsible. The highest prevalence in the mould group suggests that this is a likely source but given the small group size, only the differences in wheeze were statistically significant.

3. **Was TCPA involved?:** The finding of specific IgE antibody to TCPA addresses the third objective, indicating that immunologic or sensitization reactions to TCPA have occurred, and probably had some role in previous breathing problems. Several points support a work-place etiology for the positive antibody results: First, no office workers with the lowest exposure were antibody positive; second, there was a significant trend with duration of exposure; third, the highest prevalence of positive results was in the mould and intermittent groups, those with the greatest potential for exposure; and fourth, none of the new hires have developed antibody. The fact that new hires have not been sensitized may imply that more recent lower exposures (and recently taken measures such as ventilation) will prevent this. However, it is also consistent with insufficient time to become sensitized.

On the other hand, those sensitized were neither more likely to report symptoms over the 3 months prior to the survey nor to demonstrate a decline in FEV_1 over the shift. Interpretation of these findings is difficult because the exposures documented at the time of the survey in July

were much lower than those demonstrated previously (for example, TCPA exposures in May 1990 varied from about 5 to 20 times as high as those in July 1990.). In fact, all but one TCPA air concentration measured in July was below 0.1 mg/m^3, the new MOL Working Exposure Guideline (WEG), and the level below which no cases of known TCPA-induced OA reacted on TCPA challenge testing in a recent UK study (Venables and Newman Taylor, 1990). Thus, under the exposure conditions on the survey day (and subsequent sampling in November 1990), it would have been very difficult to demonstrate significant declines in FEV_1 even if "true" cases of TCPA-induced OA were present.

The fact that sensitization to TCPA developed in workers in Coil Assembly (i.e. among those not directly working with TCPA) is not surprising for the following reasons: first, this department was close to the moulding area; and second, air sampling indicated exposure to TCPA throughout the plant. The July air sampling showed exposure to be lower in Coil Assembly than in Moulding and premoulding.

Persistence of symptoms: Venables et al (1987) studied seven subjects with TCPA-induced OA at least 4 years following cessation of exposure. All reported improvement after leaving the factory but they still reported symptoms, and five still required therapy. Symptoms were provoked by non-specific irritants and histamine reactivity was slightly increased in all five patients tested.

4. **TCPA antibody and smoking:** The finding of higher proportions of antibody positive subjects among never and ex-smokers is contrary to that reported in the British study by Venables et al (1985), in which current smokers composed 83% with high levels of TCPA binding and 48% with low binding, and the prevalence of specific IgE antibody to TCPA was 2.2% among ex- and non-smoking factory workers vs 12.7% among current smokers. The reason for the opposite pattern at Alcom is not yet known.

5. **Current conditions at Alcom:** Initial discussions during the winter of 1990-91 suggest that the prevalence of symptoms has declined. Considering the lower exposures now demonstrated, this is consistent with a role for TCPA in the respiratory symptoms in the past, and with the conclusion that the exposures have now been adequately controlled. In fact, the MOL WEG is now being achieved in essentially all air samples.

RECOMMENDATIONS

1. To determine which subjects, if any, with persistent symptoms (especially if IgE positive) may be true cases of TCPA OA, would require clinical follow-up by a respiratory specialist with knowledge of OA using serial peak flow studies or methacholine challenges while at and away from work or conceivably, inhalation challenge with TCPA.
2. It may be reasonable to survey new hires for symptoms (and IgE antibody or skin tests) some time, such as 1 year after hire, to confirm that the problem is controlled.
3. If exposures remain low (i.e. in the range of current exposures), there is probably no health risk associated with having a positive antibody test. It is possible that IgE antibody may be associated with the development of TCPA-occupational asthma if prolonged exposure to high levels of the material occurred but prospective data would be needed to answer this with more certainty. It may, thus, be reasonable to set up a program of medical surveillance to ensure that adverse respiratory problems do not develop in the future. A program of medical surveillance may include pre-placement and periodic medical examinations and pulmonary function tests, and periodic education in the health effects of TCPA. Periodic pulmonary function tests would ideally be performed on a pre- and post-shift basis. Determination of the presence of antibodies to TCPA may be useful in confirmed cases of OA, to demonstrate sensitization.

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TABLE 1

TCPA EXPOSURE DATA
ALCOM Ltd, Port Colborne, Ontario

DATE	LOCATION	NO. OF SAMPLES	TYPE OF SAMPLE	MEAN TCPA CONCENTRATION (MG/M^3)
Oct 13, 1989	preforming	1	area	0.23
	moulding	3	personal	0.27
	moulding	3	area	0.36
May 1, 1990	preforming	1	area	0.29
	moulding	4	personal	0.40
	leak testing	1	area	0.21
	winding stn	1	area	0.28
	crimping	1	area	0.20
July 16, 1990	preforming	1	personal	0.13
	preforming	1	area	0.08
	moulding	5	personal	0.02
	moulding	2	area	0.02
	winding	1	personal	0.009
	soldering	1	personal	0.009
	finishing	2	personal	0.01
November 23, 1990	preforming	1	area	0.03
	moulding	6	personal	0.04
	moulding	3	area	<0.01*
	leak testing	1	area	<0.01
	winding	1	area	0.01
	front office	1	area	<0.01

Exposures to TCPA on the day of the survey (July 16, 1990) and in November 23, 1990 are the lowest measured by the Ministry of Labour.

* < means less than

TABLE 2

REPORTED SYMPTOMS and SMOKING STATUS DURING 3 MONTHS PRIOR TO THE SURVEY
ALCOM Ltd, PORT COLBORNE, ONTARIO
July 1990

Symptom	No (%)	Exposure Group				p^a
	Total	1	2	3	4	(p^b)
Wheeze	29(56)					
Wheeze-WR	14(27)	4(57)	0	10(30)	0	.049 (.138)
SOB	25(48)					
SOB-WR	15(29)	1(14)	1(17)	12(36)	1(17)	.475 (.489)
ChT	29(56)					
ChT-WR	20(39)	5(71)	2(33)	12(36)	1(17)	.208 (.274)
OA	18(35)	4(57)	1(16)	12(36)	1(16)	.345 (.549)
Smoking:						
Never	18(35)	0	3(50)	12(36)	3(50)	.383
Current	27(52)	5(71)	2(33)	18(55)	2(33)	
Ex	7(13)	2(29)	1(17)	3(9)	1(17)	
Total	52(100)	7(100)	6(100)	33(100)	6(100)	

LEGEND:
a by chi-square analysis
b adjusted for smoking status.
WR = work-related (see text)
SOB = shortness of breath
ChT = chest tightness
OA = occupational asthma (as defined in text)
Exposure Group 1 = Mould; 2 = Utility, maintenance, supervisor (see text); 3 = Coil assembly; 4 = Office, not in plant

TABLE 3

REPORTED WORK-RELATED SYMPTOMS ACCORDING SMOKING STATUS
ALCOM Ltd, PORT COLBORNE, ONTARIO
July 1990

Symptom	Number (%) Smoking Status			p^a
	Never	Current	Ex	
Wheeze-WR	2(11)	10(37)	2(29)	0.157
SOB-WR	5(28)	8(30)	2(29)	0.991
Cht-WR	6(33)	11(41)	3(43)	0.854
OA	4(22)	11(41)	3(43)	0.391
Decline in FEV_1 > 10%	2(11)	3(11)	1(17)	0.971
Total	18(100)	27(100)	7(100)	

LEGEND: see Table 1
a = by Chi-square

TABLE 4

FINDINGS ON SPIROMETRY (BREATHING TESTS)
ALCOM Ltd, PORT COLBORNE, ONTARIO
July 1990

Breathing Test	Exposure Group 1	2	3	4	p
Baseline					
FEV_1 pred (%)	94.0[a] (16.8)	85.2 (25.7)	94.9 (13.5)	98.5 (12.8)	0.235[b]
FEV_1/FVC ratio	84.4 (12.8)	73.7 (15.4)	81.2 (6.2)	77.0 (6.0)	0.070[b]
Change over shift					
FEV_1 (post-pre)/pre x 100 (%)	-4.1 (2.0)	-1.7 (4.2)	-3.3 (7.3)	2.5 (3.2)	0.217
Decline > 10% No (%)	0	0	6(18)	0	0.272
Total	7	6	33	6	

LEGEND: Exposure Group 1 = Mould; 2 = Utility/ maintenance (see text); 3 = Coil assembly; 4 = Office, not in plant.
[a] = mean +- (standard deviation)
[b] = p value for regression coefficient for JOBCODE after adjusting for packyears of smoking.

(Smoking, as expected, was a significant predictor of breathing function: p for packyears = 0.0015 for FEV_1 percent of predicted and 0.0398 for FEV_1/FVC ratio, after adjusting for JOBCODE).

TABLE 5

SYMPTOM AND BREATHING TEST RESULTS BY ANTIBODY STATUS[a]
ALCOM Ltd, PORT COLBORNE, ONTARIO, 1990

Symptom or test result	IgE +ve[c] No (% of 14)	IgE -ve[d] No (% of 26)	p[b]	IgG +ve No (%)	IgG -ve No (%)	p
Wheeze-WR	2 (14)	10 (38)	0.112	5 (29)	7 (30)	0.944
SOB-WR	4 (29)	8 (31)	0.885	4 (24)	8 (35)	0.443
ChT-WR	4 (29)	11 (42)	0.392	7 (41)	8 (35)	0.680
OA	3 (21)	10 (38)	0.273	6 (35)	7 (30)	0.746
FEV_1[e]	92.9+20.1	95.2+12.6	0.648			
FEV_1/FVC ratio	79.1+12.0	81.3+7.6	0.483			
Decline > 10%	2 (14)	3 (12)	0.802	3 (18)	2 (9)	0.397
Smoking Status [No (%) +ve]:						
Current	3 (16)	16 (84)	0.05	4 (21)	15 (79)	0.027
Ex	4 (57)	3 (43)		5 (71)	2 (29)	
Never	7 (50)	7 (50)		8 (57)	6 (43)	
Duration employed (yr)[f]	2.3+1.8 (n=15)	2.5+2.7 (n=34)	0.826			
Duration among those hired since 1988[f]	1.6+0.5 (n=12)	1.0+0.7 (n=24)	0.013			
Total	14 (100)	26 (100)		17 (100)	23 (100)	

LEGEND: see Table 1; [a] Only includes those participating in July survey;
[b] by chi-square (except for variables with mean +- std deviation, then t-test)
[c] Positive; [d] Negative; [e] Percent of predicted (mean +/- standard deviation)
[f] Among all those with serum available

TABLE 6

RELATIONSHIP BETWEEN EXPOSURE GROUPS, DURATION OF EMPLOYMENT AND ANTIBODY STATUS
ALCOM Ltd, PORT COLBORNE, ONTARIO, 1990

A. By exposure Groups*

Antibody status	Total [Number (%) Positive]	1	2	3	4	p	p (Trend)
IgE	15 (30)	3 (43)	4 (67)	8 (24)	0	0.085	0.05
IgG	19 (38)	4 (57)	4 (67)	11 (33)	0	0.115	0.035
Total	50 (100)	7 (100)	6 (100)	33 (100)	4 (100)		

B. By duration of employment among those hired since 1988

		Duration of Employment (years)				
Antibody status	Total [Number (%) Positive]	< 0.33	0.33-1.33	> 1.33	p	p (Trend)
IgE	12 (33)	0	4 (25)	8 (53)	0.058	0.019
IgG	15 (42)	1 (20)	5 (31)	9 (60)	0.153	0.065
Total	36 (100)	5 (100)	16 (100)	15 (100)		

* LEGEND: Exposure Group 1 = Evermould (in year prior to survey); 2 = Utility/ maintenance (see text); 3 = Coil assembly; 4 = Office, not in plant.
Includes all 50 with antibody determinations

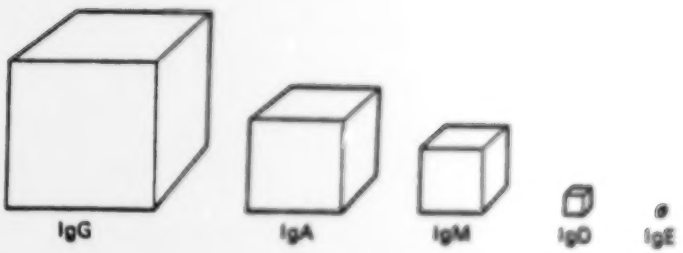

*Fig.3.1. Relative amounts of the five immunoglobulin classes in normal serum. It was impossible to make the IgE cube small enough (IgG = 12 mg/ml; IgA = 2 mg/ml; IgM = 1 mg/ml; IgD = 30 μg/ml; IgE = 50 ng/ml).

Immunoglobulin structure

Heavy and light chains

All immunoglobulin molecules are composed of *two heavy (H) chains and two light (L) chains* of polypeptides, linked together by disulphide bonds (Fig.3.2). The five kinds of heavy chains are identified by the Greek letter equivalent of their class name: gamma (γ), alpha (α), mu (μ), delta (δ) and epsilon (ε). The light chain types are called kappa (κ) and lambda (λ).